Profitability of erosion control with cover crops in European vineyards under consideration of environmental costs

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Abstract

Vine cultivation on slopes causes serious erosion with significant losses of nutrients, organic matter and water, followed by an overall loss of soil biodiversity and ecosystem services (ES). Cover crops (CC) in inter-rows can reduce these effects, but are often renounced by winegrowers due to economic causes. Soil erosion rates obtained from field data and simulations with ORUSCAL (Orchard RUSle CALibration) lay the basis for comparing three different scenarios of soil management; conventional tillage (CT), temporary cover crops (TCC) and permanent cover crops (PCC). We use the Policy Analysis Matrix (PAM) to include on- and off-site costs of erosion and to demonstrate their economic implications. The scenarios are calculated for two different European wine regions, Montilla-Moriles (Spain) and Carnuntum (Austria).

Results from ORUSCAL show that erosion is decreased in most cases with increasing use of vegetation cover. Overall, the consideration of erosion costs in the budget of farmers has only minor effects on their competitiveness and additional costs for CC are not covered by private erosion cost savings. However, if social erosion costs are added, CC are cost-effective in both regions. This is even without the valuation of non-marketed ecosystem services such as cultural and aesthetic aspects which most likely will increase social costs of erosion.

Furthermore, our results show that higher revenues are of greater importance for management decisions than lower input prices. Therefore, CC should be rewarded either through a higher willingness to pay from consumers or government support.

Keywords

Cover crops, erosion, vineyard, environmental costs

1 Introduction

A relevant negative effect in agriculture is erosion, particularly in vineyards which are often situated on slopes. Even though permanent crops account only for 2.6 % of land cover in the EU, 10 % of the total soil loss is located on these fields (Panagos et al., 2015). Erosion means not only a simple loss of soil, but rather includes a significant loss of nutrients, organic matter and water, followed by an overall loss of soil biodiversity (Pimentel et al., 1995, p. 1120; Pretty et al., 2000, p. 124). This can affect not only productivity but also composition of the terroir[1], which is a relevant quality factor for wine production and marketing. For example Panagos et al. (2018, p. 478), estimated an annual productivity loss per ha of 0.797 % in Spain and 0.888 % in Austria for arable crops due to erosion.

From an economic point of view, consequences of erosion can be grouped in on- and off-site costs, whereas on-site costs are borne by farmers and include the productivity loss and restoration of soil properties. Off-site costs such as damages to infrastructure and environment are borne by society (Galati et al., 2015, p. 558; Görlach et al., 2004, p. 10) and account for 70 % - 94 % of the total erosion costs (Görlach et al., 2004, p. 33).

The predominant soil management method in vineyards is bare soil, which intensifies erosion. Bare soil management is based on the application of herbicides or mechanical weeding. The extent of erosion and associated on- and off-site costs can therefore be determined by farming practices. Conservation technologies e.g. no tillage systems, mulching or the use of cover crops (CC) can reduce erosion significantly (Bagagiolo et al., 2018; Gómez et al., 2011; Ruíz-Colmenero et al., 2013). Cover cropping has a long tradition as an erosion control method and

[1] Terroir derives from French and comprises the whole environmental conditions (e.g. climate, soil, landscape) which are responsible for the distinctive character of wine areas.

for improving soil health in vineyards but was mostly given up during the rise of synthetic fertilisers and pesticides in the 20th century (Ingels, 1998, p. 4). In Table 1 advantages and disadvantages of CC are summarized.

Table 1: Advantages and disadvantages of cover crops

Several studies (e.g. Begum et al., 2006; Berndt et al., 2006) have explored effects of cover crops on pests. CC might improve pest control but can also provide habitat for pests. This is determined by plant species composition. Soil properties such as soil organic carbon and aggregate stability can be improved with CC (Guzmán et al., 2019) and Galati et al. (2015) shows that CC reduce loss of nutrients and organic matter by 60 %. If legumes are seeded, nitrogen can be fixed in the soil. Moreover, a meta-analysis has documented that CC have large positive effects on biodiversity and various ecosystem services (ES) (Winter et al., 2018).

As winegrowers usually only calculate on-site costs and ignore off-site costs, they often associate conservation technologies with higher management costs and reduced competitiveness (Marques et al., 2015; Schütte and Bergmann, 2019). These costs occur in the short-term, while a decreasing productivity due to erosion is showing in the long-term and can be deferred by increasing fertilizer use. For instance, assuming an average soil loss rate of 9.47 t/ha under permanent crops (Panagos et al., 2015, p. 442), it will take approximately 200 years until the fertile topsoil is lost completely. Thus, the risk of productivity loss through erosion is not necessarily a main concern of winegrowers.

Based on this unsustainable situation, there is a demand for societal actions. Agricultural policy can influence farming behaviour and policies can be used to decrease negative external effects of agriculture (Kydd et al., 1997, p. 335).

The Common agricultural policy (CAP) of the EU promotes agri-environment measures (AEMs) and for example subsidises soil conservation methods such as CC in vineyards. AEMs compensate farmers for voluntary conducted extensive management practices. Member states (MS) are individually responsible for the configuration of AEMs, thus their implementation is characterized by a large diversity across EU. The contrast is obvious when focusing on the proportion[2] of farmers receiving payments from AEMs which is highest in Austria (97 %) and lowest in Spain (3 %) (Zimmermann and Britz, 2016). However, these subsidies mostly cover on-site costs of farmers and do not necessarily present a sufficient incentive for those to change their behaviour (Galati et al., 2015).

Pannell (2008, p. 239) emphasises that it is important to acquire information about private and social net benefits of the targeted land management change, in order to choose an appropriate policy measure. In particular, knowledge about private net benefits helps to anticipate potential acceptance of these changes from practitioners. Martínez-Casasnovas and Ramos (2006) also point out that there is insufficient knowledge about economic implications of erosion and underline the importance of this knowledge for farmers and politicians.

The aim of this study is to create better understanding about environmental effects and the associated cost structure of erosion control in European vineyards. It reveals necessary data

[2] Based on data from the Farm Accountancy Data Network (FADN) and the time period 2000–2009

about private and social net benefits of CC in vineyards and illustrates, why winegrowers might hesitate to adopt CC. Hence, this study contributes to the ongoing political discussion about sustainability in agriculture and the economically reasonable assignment of subsidies.

For this study we compare different soil management scenarios in two European wine regions, namely Montilla-Moriles in Spain and Carnuntum in Austria. In regions with high intensity rainfalls for example in Andalusia (Spain), huge amounts of soil are washed away during autumn and spring and gullies are typical sights (Rodrigo Comino et al., 2017). The intensity of rainfalls may also increase in Austria as a consequence of climate change (Klik and Eitzinger, 2010) and increase water erosion. While in Montilla-Moriles bare soil management is predominant, in Carnuntum a wide variety of soil management can be observed with a clear tendency towards cover cropping. These regions are contrasting but exemplary for the large diversity in European viniculture.

The budgetary Policy Analysis Matrix (PAM) is used to reveal the effect of CC adoption and erosion prevention on the profitability of winegrowers. This method enables the calculation of different competitiveness ratios, which are used to compare the case studies. Even though the PAM is a static methodology, its strengths are a clear presentation and an easy comprehensibility of results, which makes them particularly accessible for stakeholders and useful for policy counselling. Results from ORUSCAL (Orchard RUSle CALibration) and experimental plots underline the calculation of the economic effects of CC for winegrowers and society.

2 Methodology

2.1 Study areas

Data for this study was collected in two European wine regions, both labelled as a protected designation of origin (PDO), within the VineDivers project[3].

The region Montilla-Moriles covers some 5 000 ha close to Cordoba in Andalusia, Spain. Around 2 000 winegrowers produce 276 000 hectolitres of white wine of which 90 % is placed on the national market (Montilla-Moriles, 2016). The soil is shaped by laminar structures and high carbonate content and Luvisols and Cambisols are the predominant soil types. The semi-continental Mediterranean climate leads to an average annual precipitation of 604 mm (range: 306 – 1 012 mm) and a mean annual temperature of 17.2 °C (Guzmán et al., 2019). Bare soil is the major management method, although using CC has been increasing over the last decades. Vegetation cover, mostly temporary during autumn/winter, is only used on about 10 % of Montilla-Moriles vineyards. In some cases, the traditional management without trellis aggravates the implementation of CC. The increasing CC use is partly affiliated to CAP regulations, which stipulate CC on sloping areas above 10 %, but is also due to certified agricultural systems e.g. organic production. The economic situation for businesses is tough as grapes are sold mostly to cooperatives and Montilla-Moriles competes with the area of Jerez which produces similar wine, but is better known on the market. Additionally, more profitable olive and almond orchards are competing for land. Therefore, the cultivated area and the number of winegrowing businesses were reduced by half since 2000 (Ministerio de Agricultura, Pesca y Alimentación, n.d.).

[3] www.vinedivers.eu

Carnuntum is a small PDO of roughly 900 ha under vine and about 150 winegrowers, which is close to the Austrian capital Vienna. Loess and gravel (on the slopes) are the predominant soils and the area is characterized by its Pannonian climate with cold winters and dry, warm summers (Österreich Wein, 2018a). The average temperature is 11.6 °C and the annual precipitation reaches 473 mm (Winter, 2015). The production amounts to 43 000 hectolitres, about half white and red wine (Österreich Wein, 2018b: 36). The use of CC is already widespread in the region but bare soil can also be seen. Due to its touristic attractiveness and proximity to Vienna, the region is oriented towards direct marketing and many winegrowers produce their own wine.

2.2 Orchard RUSle CALibration (ORUSCAL)

ORUSCAL is an Excel tool which allows the calibration of RUSLE2 (Dabney et al., 2012) by assuming a simplified situation of a homogeneous hillslope for tree crops. The structure is defined in Appendix A. Each of the factors of RUSLE2 is calculated in one (e.g. R) or several (e.g. C) Excel sheets (Dabney et al., 2012). Each factor is accompanied by a set of explanations. The sheets contain information, or procedures for finding this, to allow users to include the required data and to calibrate the parameters. All equations and units have been revised to agree with those employed in RUSLE2. The assumption is that with basic information on rainfall, temperature, crop evolution, canopy and ground cover, tillage and topography it is possible to calibrate RUSLE2, considering the interactions among different factors and sub-factors in a straightforward way. This can facilitate understanding the erosion risk of different management practices by stakeholders, or enables more sophisticated uses such as comparison of erosion risk among different management, soil, hydrological and rainfall regimes. For more complex situations, e.g. complex slope profiles, users should calibrate the model using the RUSLE2 software. Literature shows a wide variability among soil cover and management (C) factors for vineyards (e.g. Auerswald and Schwab, 1999; Kouli et al., 2009; Novara et al., 2011; Pacheco et al., 2014) which complicates their interpretation and extrapolation outside the original area. Therefore this model provides a tool to perform erosion studies in vineyards using a standardized procedure, which might help to overcome this problem.

ORUSCAL was validated for four different calibration strategies, using runoff plot data for two different types of soil management from a long-term experiment conducted by Biddoccu et al. (2016). These strategies were:

a. Constant soil erodibility (K) value calculated based on soil properties from the nomograph used by standard RUSLE, and consideration of soil moisture variation during the year using the soil moisture (sm) subfactor for the determination of cover and management factor C.
b. Constant K value, calculated from soil properties from the nomograph, without considering the sm subfactor in the determination of C.
c. Variable K value, using the empirical function based on temperature and rainfall included in RUSLE2 documentation with a baseline value for K calculated from soil properties from the nomograph, without considering the sm subfactor in the determination of C as indicated by RUSLE2 handbook.
d. Constant K value calculated from soil properties based on the model proposed by Borselli et al. (2012), and considering the sm subfactor when calculating factor C.

The results, presented in Gómez et al. (2018), showed that the best calibration strategies were a and d, which both consider the sm subfactor. These calibration strategies provided the best prediction of the runoff plot data used for calibration.

Once evaluated, the model was used to assess the impact of different management scenarios on soil erosion risk, using the calibration option a. for Montilla-Moriles in Southern Spain. The topographic, soil, cover and management information required was taken from field survey of sixteen vineyards, eight for each of the two most common soil management techniques, representative for the area. The considered management techniques were low intensity management, meaning temporary cover crops (TCC) in the inter-rows during fall and winter, and high intensity management, meaning conventional tillage (CT) to maintain bare soil throughout the year.

ORUSCAL was also used to predict soil erosion in the Eastern Austrian vinicultural region Carnuntum. As in the case of Spain, topographic, soil, cover and management information required was taken from field survey of sixteen vineyards, eight for each of the two most common soil management techniques, representative for the area.

In the Austrian case low intensity management means permanent cover crops (PCC) in every inter-row throughout the year, whereas vegetation cover throughout the year in every second inter-row with tillage in every other inter-row (TCC), is considered high intensity management.

In addition, other possible but hypothetical soil management strategies, (see Table 2) were simulated for both regions. Soil properties, cover and management information used to implement the hypothetical scenarios were estimated from previous studies and available literature (Bartoli and Dousset, 2011; Celette et al., 2005; Peregrina et al., 2010; Ruíz-Colmenero et al., 2013; Salomé et al., 2016).

For both regions, daily climate data for 16 years (2000-2015) was taken from nearby weather stations. The rainfall erosivity factor (R) was calculated using an empirical expression for daily rainfall and daily erosivity calibrated to provide similar annual results to those presented at the monthly erosivity map of Europe (Ballabio et al. 2017) to prevent bias in R determination across regions.

Table 2 summarizes the number of simulated scenarios (vineyards) in each country for each year of the considered period (2000-2015).

Table 2: Scenarios for ORUSCAL simulations

Example pictures for the management scenarios can be seen in Figure 1.

Figure 1: Example pictures of the scenarios

2.3 Policy Analysis Matrix

The PAM is an approach to not only measure price distortions but also comparative advantages. Moreover, Kydd et al. (1997) demonstrates that it is possible to take monetary valued environmental effects into account. In contrast to computable general equilibrium models (CGE) the PAM concentrates on one specific commodity system. This partial equilibrium approach has moderate demands on the amount of data required and can be conducted in a shorter period of time (Hartmann et al., 1993, p. 71 f). This makes the method remarkably attractive in the context of data and time limitation. Despite the simplification, it leads to reasonable results and has been proven useful in many agricultural studies over the last decades (e.g. Nelson and Panggabean, 1991; Yao, 1997; Krabbe and Vink, 2000; Pearson et al., 2003; Lakemeyer, 2007; Abdul Fatah, 2017).

The basic PAM, as shown in Table 3, consists of three rows, whereby the first two rows display the private and social prices. The third row shows divergences between the first two rows. These divergences are the results of either market-distorting policies or market failure, e.g. external effects (Monke and Pearson, 1989, p. 14). In this matrix, the competitiveness of a production system can be spotted easily. The private profit (D), if not positive, should at least be equal to zero. Otherwise the producer will probably cease production (Monke and Pearson, 1989, p. 12). If D is positive but the social profit (H) is negative, the production system is only operating due to the protection of the government (Monke and Pearson, 1989, p. 17).

Table 3: The Policy Analysis Matrix

For constructing a PAM, information about input and output prices of production is needed. The information for private prices (A, B, C) is obtained from farm budgets. The social prices have to be estimated. For tradable inputs and outputs (D, F), world prices adjusted by marketing costs are usually a good assumption. Social opportunity costs are used for non-tradable, domestic inputs (G) such as labour and land (Pearson et al., 2003, p. 19 f).

In our analysis we added on-site costs of erosion as a non-tradable private factor and off-site costs as a non-tradable social factor to the matrix in the scenarios CT, TCC and PCC. The Basic scenario presents a CT scenario without considering erosion costs. Eventually, the matrix entries can be used to calculate some helpful indicators. These parameters are necessary for comparing different countries or production systems and are presented in Table 4 (Monke and Pearson, 1989, p. 16).

Table 4: Parameters calculated from the PAM

The social cost benefit (SCB) as well as the domestic resource cost (DRC) are used to calculate the comparative advantage of a production system. The private cost ratio (PCR) is the equivalent to the DRC in private prices, whereas the private cost benefit (PCB) is the counterpart to the SCB. As (Masters and Winter-Nelson, 1995) indicate, the DRC (and consequently the PCR) is influenced by the amount of domestic factors which are used by a commodity system and thus the SCB (equally PCB) is a more suited alternative. In addition, the DRC is discontinuous where E = F, which complicates the interpretation. The advantages and disadvantages of these two indicators have also been discussed by Nivievskyi and von Cramon-Taubadel (2009). Hence, we focus on the SCB and PCB in the results[4].

The nominal protection coefficients for output (NPCO) and input (NPCI) reveal price distortions in the respective markets. The effective protection coefficient (EPC) combines the NPCO and the NPCI and shows overall effects of price distortions (Lakemeyer, 2007, p. 94 f).

To construct the PAM, we used average primary as well as secondary data, adjusted by inflation for the year 2016. Primary data was collected during field trips and personal interviews as well as focus groups with practitioners from the regions. Grey literature was the main source for secondary data e.g. official statistics provided by regional institutions and the EU. Key sources for secondary budget information in Spain was data from Junta de

[4] For the sake of completeness, the DRC and PCR can be found in the Appendices.

Andalucia (2018, 2003) and Alcázar (2011). For Austria data from a gross margin calculator (Bundesanstalt für Agrarwirtschaft, n.d.) was used.

Estimated erosion costs in literature show a wide variety. Hereafter we concentrate on the intermediate results from Görlach et al. (2004), which represent a conservative estimation. These estimations were established through a profound literature analysis and additional field studies and are shown in Table 5. The costs are divided in on- and off-site costs which present in the former private costs and social costs in the latter.

Table 5: Costs per ton of soil loss in year 2016

This data was combined with soil loss rates from regional experiments and simulations with ORUSCAL. The amount of subsidies per hectare derives from Anderson & Jensen (2016) who estimated the entire support European wine producers received 2007-2012.

According to the OECD (2018: 195) nearly 50 % of the subsidies European farmers receive under pillar I are linked to mandatory environmental requirements e.g. cross compliance and greening. However, permanent cultures such as vineyards are exempted from greening regulations (Alliance Environment and Thünen Institute, 2017, p. 223) and winegrowers must only act according to the basic rules of cross compliance to receive direct payments (European Commission, 2015). This also applies for farmers under the Small Farmers Scheme who receive a maximum payment of 1 250 € per farm. Under pillar II farmers can participate in voluntary AEMs to receive payments for additional environmental services which account for another 8 % of the total producer support (OECD, 2018, p. 195). In Spain organic winegrowers can receive an additional payment of about 95 €/ha if they obtain CC at least in every second inter-row from October to March and the slope is above 20 % (Ramírez Pérez and Lasheras Ocaña, 2016, p. 22 f). In Austria every winegrower can receive 100 - 800 €/ha for maintaining CC, depending on the slope. TCC over the winter are only eligible on slopes under 25 %. On steeper slopes PCC have to be used (AMA, 2015). In both countries the size of the vineyard must be at least 0.5 ha to be eligibility for payments.

The models describe small family farms[5] in the study regions and are in each case calculated for one ha of vineyard on moderate slopes with a trellis system and no irrigation. The basic budgets can be found in the supplementary data.

3 Results

The distribution of costs is relatively similar in both study regions as can be seen in Figure 2.

Figure 2: Cost structure of grape production

Labour, which accounts for more than half of the budget, and capital costs (around a quarter) are the most important cost categories. The share of capital costs includes the amortisation of the vineyard. In Austria we find a slightly higher proportion of labour costs. This can be related to higher quality grapes which require more pruning and canopy work. The third largest cost category is variable machinery cost, closely followed by chemicals. Fertilizer and maintenance of the vineyard are minor categories.

Figure 3 shows that the production of grapes for wine production is not profitable in most cases (SCB resp. PCB > 1). Moreover, when comparing the scenarios Basic and CT, the consideration of erosion costs has only a slight effect on the ratios derived from the PAM in both regions.

[5] The average farm size in Montilla-Moriles is 2.3 ha and in Carnuntum: 6.2 ha.

Figure 3: SCB and PCB Ratios for Austria and Spain

3.1 Spain

The erosion simulation for Montilla-Moriles resulted in an average erosion rate under TCC (9.53 t/ha/y) slightly higher than under CT (7.14 t/ha/y) which is contrary to the hypothesis that greened vineyards always reduce soil erosion. Nevertheless, the average soil loss rate under PCC (1.64 t/ha/y) is substantial lower than under CT and follows the basic hypothesis. Under consideration of all costs and a grape price of only 0.30 €/kg, a small winegrower in Montilla-Moriles is not profitable. However, the yield covers variable costs. The SCB of 1.41 demonstrates no competitive advantage for this industry. Under the given cost structure, at least 0.41 €/kg grapes would be needed to cover full costs (SCB=1).

If the farmer is able to receive the full amount of subsidies the NPCO reaches 1.12 which demonstrates that the domestic output prices are higher than the comparable world prices and indicates domestic price distortions.

The scenarios TCC and PCC are linked to increasing management costs which account for 2.3 % (TCC) respectively 4.5 % (PCC) of the variable costs. Table 6 shows that under the solely consideration of private costs, it is unprofitable for a winegrower to change the management. From a social perspective however, PCC management saves more than it costs.

Table 6: Changes in Erosion Costs compared to CT (Montilla-Moriles)

The AEM payment of 95 €/ha covers at least the management costs for TCC.

3.2 Austria

Experimental data on Erosion rates in Carnuntum[6] show a continuously decline with the usage of CC which has been verified through the ORUSCAL simulations.

The economic situation for winegrowers in Carnuntum is better than that of their colleagues in Montilla-Moriles with a grape price of 0.90 €/kg and a SCB of 1.22, but is still not competitive. They require a minimum price of 1.10 €/kg to reach competitiveness (SCB=1). Austrian winegrowers receive more subsidies (NPCO=1.29) than their Spanish peers and can thus achieve private profitability with a PCB of 0.95.

The changed management comes with 1.8 % (2.7 %) additional costs for TCC (PCC) but, as can be seen in Table 7, they are exceeded by the saved social erosion costs.

Table 7: Changes in Erosion Costs compared to CT (Carnuntum)

Similar to the scenarios in Spain, from a private perspective the management change is not profitable. Indeed, winegrowers can participate in the AEM "erosion control" and are eligible for payments of 100 – 800 €/ha depending on the slope of the vineyard. On moderate slopes 200 €/ha are paid for PCC (AMA, 2015). This covers the additional management costs.

3.3 Sensitivity Analysis

Even though the PAM has clearly some practical advantages, it should be kept in mind, that it is a static annual approach, based on a Leontief production function. Changing production decisions based on price alterations cannot be considered. In addition, it is particularly difficult to estimate valid quantities and prices for the underlying budgets. The model is

[6] CT: 9.7 t/ha/y; TCC: 4.7 t/ha/y; PCC: 1.4 t/ha/y

unable to depict the variability of agricultural prices and the transmission of world prices to domestic prices can be deficient (Morrison and Balcombe, 2002, p. 462). Thus, to show in detail how the SCB is affected by particular factors, we conducted a sensitivity analysis on the output price as well as labour, variable machinery and erosion costs.

Table 8 shows that a change of output prices influences competitiveness more than changing input prices. It is therefore crucial for winegrowers to gain higher prices, if they want to stay on the market.

As indicated by winegrowers and derived from the cost share of labour, this factor has the second biggest effect on competitiveness in both regions. However a moderate increase in labour due to CC does not have a significant effect on the SCB ratio and indicates that it should be acceptable in respect of the gain in ES.

An alteration of the estimated erosion costs does not influence the SCB substantially. This strengthens the previous presented results and highlights the minor consequences of erosion costs for the profitability of vineyards. It also points out that even if winegrowers have to incorporate the estimated on- and off-site costs of erosion in their budget, it does not mean that the management is instantly changing to a more sustainable option.

Table 8: Sensitivity Analysis for SCB

4 Discussion

The deviation of a higher erosion rate under TCC compared to CT in Montilla-Moriles is an indicator for many different aspects (e.g. slope, rainfall events and intensity) which are involved in erosion, besides CC, and the heterogeneity in the field sites as described by

Guzmán et al. (2019). Hence, the results of the simulation do not necessarily have universal validity for the region. However, the calculated erosion rates are within the range (and trend) of observed values in experimental studies about vineyards under different soil managements as reported in a literature review (Prosdocimi et al. 2016). For example, Biddoccu et al. (2016) measured average values of 7.0 ± 12.5 t/ha for conventional tillage (CT), respectively 1.8 ± 1.6 for permanent spontaneous grass cover (GC). As noticed previously, CC bring along a series of benefits to the ecosystem and biodiversity (Winter et al., 2018) besides erosion control, and hence are always the superior management option from an environmental point of view.

If winegrowers have to take erosion costs into account, it is important to differentiate between private and social costs. Private erosion costs are lower than the additional expenses for an altered management and thus will not lead to an adoption of CC. Yet, a change towards CC is cost effective if social costs of erosion are considered.

The management change from bare soil towards CC comes with considerable low additional input costs between 1.8 % and 4.5 %. However, the sorely production of grapes is already not profitable in most investigated cases. Certainly, any consideration of additional costs will worsen the economic situation for grape producers. The integration of wine production and marketing into businesses can improve their profitability and is one explanation why winegrowers remain in business. Winegrowers, who produce their own wine and are involved into direct marketing, generate added value and can influence the pricing of their products. Prices of bottled wine show a tremendous range. This cannot be explained solely by different qualities but especially by successful marketing. The touristic development of wine regions offers major potential to establish higher prices and the use of CC can have an additional effect, considering the ongoing trend for sustainable consumption. In that case, a management change towards TCC or PCC should not represent a serious economic threat to businesses.

If higher market prices cannot be realized, additional incentives through AEMs could reward environmental services by winegrowers. However, one needs to be aware that winegrowers might not adopt these measures at the extent intended. Intensively managed lands, small scale farms, a high share of family labour and reliance on agricultural income reduce the willingness to adopt AEMs (Lastra-Bravo et al., 2015; Zimmermann and Britz, 2016) but are characteristics of vineyards in the studied regions.

In this context we enhance the discussion about the appropriate political treatment of this subject. According to Pannell (2008) policy instruments have to be chosen in compliance to public and private net benefits. Pannell recommends "positive incentives where public net benefits are highly positive and private net benefits are close to zero" (ibid.: 239) which underlines once more the relevance of knowledge about erosion and the associated economic costs and benefits. However, the implementation of financial aid for environmental services in agriculture can be criticized and offers space for discussions. AEMs imply that policy has decided that winegrowers have the right to exploit their land and should be compensated for environmental services instead of ascribing society a right for a healthy environment. This allocation of property rights developed historically and is not uncritical (Bromley and Hodge, 1990). The question of property rights of environment have been widely discussed in environmental economics. Following Coase (1960) it does not matter who owns these rights as negotiations will always lead to an efficient allocation of resources. However, Coase's concept is of theoretical nature and does not hold true in a realistic setting with transaction costs and information asymmetries. Cerin (2006, p. 222) comes to the conclusion that environmental related altruistic behaviour cannot be expected of companies, particularly if it is not appreciated by consumers. Hence, in its current state, the CAP acknowledges that "farmers should be rewarded for the services they deliver to the wider public, such as landscapes, farmland biodiversity, climate stability even though they have no market value" (Dg Agri, 2013, p. 5).

Although the NPCOs in both regions are above one, which represents governmental support, it should be noted that many small winegrowers do not apply for subsidies due to bureaucratic barriers. Moreover, a considerable amount of subsidies in viniculture is paid for promotion activities and investments into cellars which might not affect all winegrowers equally. Therefore, the inclusion of subsidies in the PAM is more of a hypothetical scenario and illustrates a best case for farmers.

The incentive for maintaining CC in vineyards through AEMs can be considered very low in both study regions. For the payments many liabilities must be respected e.g. in Spain vineyards have to be ecological and on slopes over 20 % (Ramírez Pérez and Lasheras Ocaña, 2016). AEM payments neither give further financial incentive nor incorporate social costs of erosion or potential learning costs (Pannell, 2008). This coincides with the results of Galati et al. (2015).

It is important to underline the limitations of this study. The estimation of erosion costs is a challenging endeavour. Different approaches such as the replacement cost (e.g. Martínez-

Casasnovas & Ramos 2006) or productivity change method (e.g. Panagos et al. 2018) can be found in literature and achieve different results. Considering that estimations often fail to incorporate non-market values such as biodiversity and aesthetics, the real total costs of erosion are most likely higher than assumed in this study. Yet, even though erosion costs were subject to a sensitivity analysis, we could not determine a significant effect on the profitability of winegrowers since the share of the total input costs remains smaller than that of other cost positions such as labour. Especially the costs of productivity losses are negligible. Hence, although erosion is most likely a non-linear process, in this study we decided to refrain from a discounting factor and to follow a static annual framework, with the assumption that it is valid for a medium short-term analysis. In this period soil loss will not result in a collapse of soil water balance for vines. The time span for a significant productivity loss would probably exceed the life time of winegrowers and has therefore little effect on their current management behaviour. In addition, the utility of discounting factors for natural resources such as soil is at least discussable as presented by Görlach (2004: 60).

The data of this study is case specific and not representative. It will be difficult to transfer the results to other vinicultural areas, especially as viniculture is very diverse in itself, not only on the production side, but also in regard to marketing. Output prices show a tremendous variance, which are not sorely linked to production costs but rather to superior marketing competencies. Future research should extend these results to a larger scale to reach representativeness and overcome the limitations of the static approach. It might also be of particular interest to investigate how winegrowers could use CC for marketing purposes.

Even though in the long-term winegrowers benefit from a stable wine quality based on the saved terroir, their management needs to change in the short-term. Yet, more restrictive environmental regulations could drive winegrowers out of business due to their already difficult financial situation. If policy wants to prevent this situation while further improve biodiversity, supporting CC through regional adjusted AEMs should be continued. Since the current AEMs only cover the direct management costs of CC, an increase of payments which reward further saved social costs and cover learning costs could be discussed.

5 Conclusion

Soils are remarkable systems and their biodiversity plays an important role in providing ecosystem services. At its most basic, "terroir" is also a relevant quality factor for wine strongly related to the land and climate where grapes are grown. Therefore, protection of this valuable source should be of high priority to winegrowers. Cover crops reduce soil erosion and provide a series of other ecosystem services, on-site as well as off-site, which makes them an ideal management practice from an environmental point of view. This has been documented throughout related literature. However, the associated economic implications were often not considered.

Our results show that CC tend to increase production costs, mainly due to higher labour needs. Especially for family-owned vineyards labour is a constraining factor. Winegrowers in Montilla-Moriles already work on the edge of profitability, if only variable costs are included. In this region grapes are sold for a low price of 0.30 €/kg. It is plausible, that there are more urgent concerns than the long-term protection of terroir and biodiversity. In

Austria we have a different situation. Here winegrowers realize higher output prices (0.90 €/kg), and are generally better positioned on the market than their Spanish peers, since they mostly generate added value through the production and marketing of their own wine. CC are even used out of marketing reasons. The results demonstrate that not only the production costs are relevant for management decisions of vineries but also the retail price. Nevertheless, if all on- and off-site costs are considered, CC are cost-effective in both regions. This lines up with the findings of Keesstra et al. (2018), who conclude that nature based solutions are a cost-effective solution to tackle land degradation. This is even without the valuation of non-marketed ecosystem services such as cultural and aesthetic aspects. Even though only annual costs are presented, this data gives valuable insights into the present economic situation of European winegrowers. However, due to many uncertainties in environmental economies, the presented costs of erosion are most likely underestimated. European winegrowers need different levels of encouragement and reimbursement for their short-term costs and their provision of external ecosystem services. However, encouraging increasing output prices can have an effect on the implementation of sustainable practices as well.

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Declaration of interest

The authors declare that they have no relevant or material financial interests that relate to the research described in this paper.

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Appendix A - ORUSCAL

Figure A.1: General layout of ORUSCAL